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Sensory Quality Evaluation of Robusta Coffee Beans as Influenced by Drying Methods and Load Volume

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ABSTRACT

This study evaluated how drying methods and load volume influence the sensory quality of Robusta coffee beans in Banga, South Cotabato, Philippines. Specifically, it examined the effects of three drying systems—bare concrete, portable drying beds, and a dryer with plastic cover—and three load volumes of 5, 10, and 15 kg/m² on drying performance, moisture content, and cup quality attributes. A two-factor factorial experiment arranged in a Completely Randomized Design with three replications was conducted. Freshly harvested Robusta coffee cherries were selectively harvested, sorted, washed, and subjected to assigned drying treatments until beans reached safe moisture levels. Sensory evaluation was conducted using standard cupping protocols by trained panelists, and data were analyzed through ANOVA and LSD at the 5% level of significance. Results showed that drying method significantly affected drying duration and final moisture content, with bare concrete drying the fastest and the plastic-covered dryer recording the longest drying period. Load volume did not significantly affect drying duration and moisture content. However, load volume significantly influenced salt–acid balance, overall cup quality, and cup score, while both drying method and load volume significantly influenced bitter–sweet balance. The 15 kg/m² load volume consistently produced higher sensory ratings, and the best treatment combination was the dryer with plastic cover at 15 kg/m². These findings indicate that optimizing load volume, particularly at 15 kg/m², is critical for enhancing Robusta cup quality, while controlled drying environments may further improve sensory stability and market value.

Keywords*: Drying Method, Load Volume, Moisture Content, Postharvest Processing, Robusta Coffee, Sensory Quality*

INTRODUCTION

Coffee is more than a beverage in the Philippines; it is part of livelihood, social life, and cultural identity. Its sensory expression is shaped by variety, environment, and postharvest handling, with Robusta coffee being especially important in Philippine production. Robusta accounts for a major share of national coffee output, and Sultan Kudarat remains one of the leading coffee-producing provinces, although productivity and quality remain affected by postharvest limitations and inconsistent processing practices (PSA, 2023, as cited by Agna, 2024).

Postharvest processing is a critical determinant of coffee quality because drying influences moisture stability, microbial safety, physical defects, and sensory attributes. Drying reduces bean moisture to safe levels, limits spoilage, and preserves desirable flavor precursors (Haile & Hee Kang, 2020; Ehrenbergerová et al., 2021). However, traditional sun-drying practices are highly dependent on weather, airflow, and farmer management, which may cause uneven drying, prolonged moisture retention, or flavor deterioration.

Drying method and load volume are two practical variables that farmers can manage. Drying systems such as bare concrete floors, raised portable drying beds, and plastic-covered dryers create different microenvironments in terms of temperature, humidity, and airflow. Load volume, or the amount of coffee placed per square meter, affects layer thickness and moisture movement. If beans are loaded too densely, airflow may be restricted; if spread too thinly, drying may be rapid but less favorable for gradual biochemical development (Basalong et al., 2021).

Given the importance of Robusta coffee in South Cotabato, this study evaluated the effects of drying method and load volume on drying performance, moisture content, and sensory quality. The findings provide practical guidance for smallholder farmers and processors seeking to improve postharvest quality, enhance cup performance, and strengthen the competitiveness of local Robusta coffee.

Literature Review

Coffee Drying Methods and Drying Duration

Drying method determines the rate and uniformity of moisture removal, which directly influences bean integrity and cup quality. Mechanical and semi-controlled dryers provide more stable heat and airflow, reducing thermal gradients and minimizing structural defects such as cracks, splits, and uneven shrinkage (Ghosh & Venkatachalapathy, 2014; Abreu et al., 2025). Traditional sun drying remains common among smallholder farmers because of its simplicity and low cost; however, it is more vulnerable to weather variation and uneven exposure.

Raised drying beds and greenhouse-type dryers improve drying conditions by allowing air circulation and reducing direct contact with contaminated surfaces. Greenhouse or plastic-covered systems provide semi-controlled conditions that may better preserve flavor compounds while reducing environmental contamination (Abreu et al., 2025; Peñuela Martínez et al., 2023).

Effects of Drying Method and Load Volume on Cup Quality

Coffee cup quality is affected by the preservation or degradation of volatile compounds, sugars, organic acids, and phenolic compounds during drying. Slow or uneven drying may alter flavor precursors and produce off-flavors such as woody, papery, or harsh bitter notes (Avallone et al., 2018; Montavon et al., 2003). Controlled drying can reduce these risks by regulating airflow, temperature, and humidity.

Load volume is equally important because it determines the thickness of the coffee layer. Thin layers promote faster moisture movement, while thicker layers may slow drying and influence biochemical changes. Prior research suggests that load volume and layer thickness affect moisture uniformity, defect formation, roasting behavior, and sensory consistency (Basalong et al., 2021; Musebe et al., 2007; Van der Vossen et al., 2019).

Interaction Between Drying Method and Load Volume

The drying method and load volume interact through the drying microenvironment. A well-designed drying structure may lose its benefits when beans are overloaded, while an optimized load volume may still be affected by unstable airflow or humidity. Thus, coffee quality is not determined solely by the drying structure but by how effectively the structure and bean load support uniform heat and mass transfer (Jakkaew et al., 2024; ICO, 2005).

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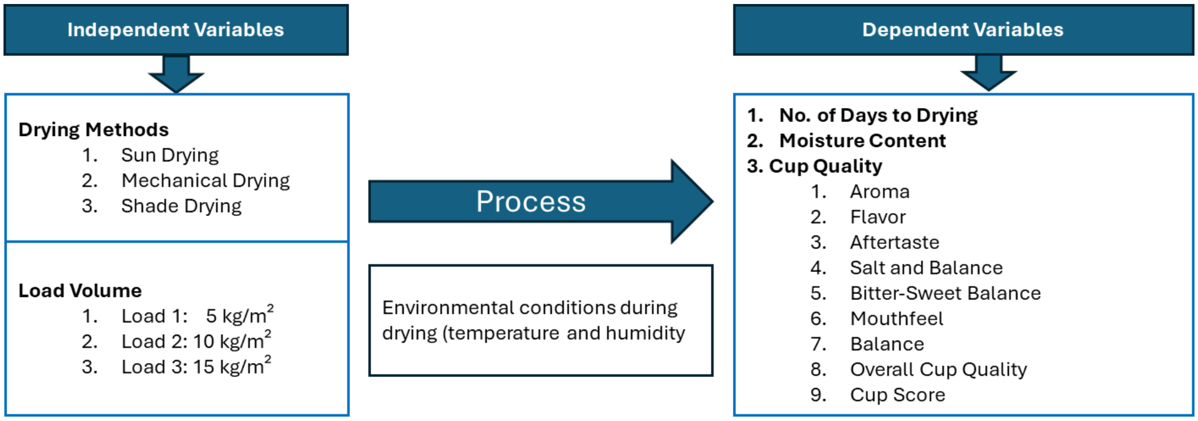

Figure 1. *Conceptual framework of the study.*

METHODS

Research Design

The study used a two-factor factorial experiment arranged in a Completely Randomized Design. Factor A was drying method with three levels: bare concrete drying floor, portable drying bed, and dryer with plastic cover. Factor B was load volume with three levels: 5 kg/m², 10 kg/m², and 15 kg/m². Each treatment combination was replicated three times.

Research Locale

The study was conducted in Barangay Rizal, Municipality of Banga, South Cotabato, Philippines, from February to March 2026. Freshly harvested Robusta coffee cherries were obtained from Barangay Kinilis, Polomolok, South Cotabato. The area is characterized by a tropical climate with warm temperature and relatively high humidity, both of which are relevant to coffee drying behavior.

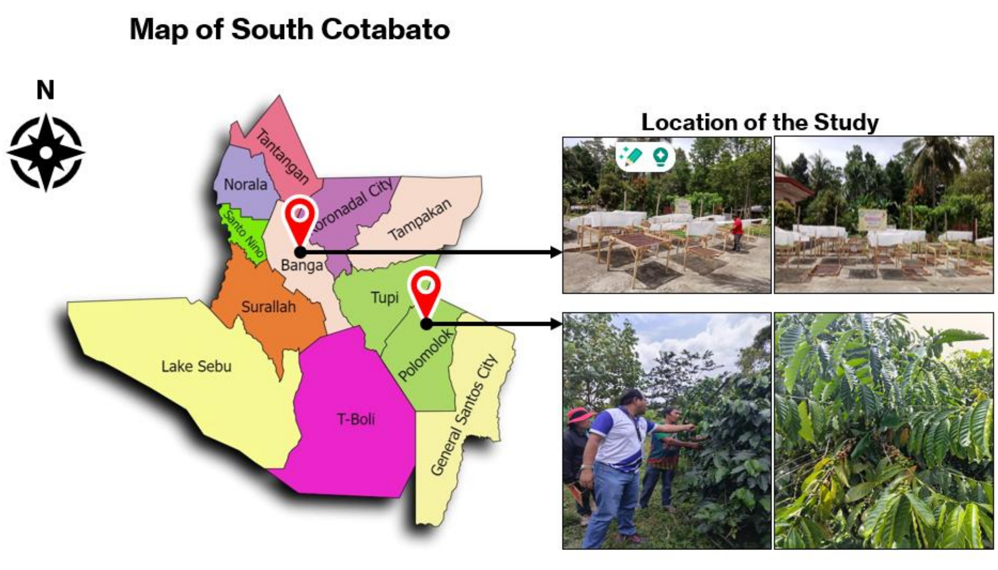

Figure 2. *Location of the study in South Cotabato*

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Materials and Drying Systems

The study used freshly harvested Robusta coffee cherries, bare concrete drying floor, portable drying beds, and a plastic-covered dryer. The portable drying beds and plastic-covered dryer used raised wooden frames with mesh flooring to facilitate airflow. Instruments included digital thermohygrometers, coffee moisture meters, light meters, digital weighing scales, sampling containers, and cupping materials such as a coffee huller, sample roaster, grinder, cupping bowls, cupping spoons, and Specialty Coffee Association cupping forms.

Figure 3. *Experimental dryer designs and drying set-up*

Data Collection Procedure

Robusta coffee cherries were selectively harvested by hand, and only fully ripe red cherries were retained. The cherries were sorted to remove unripe, overripe, diseased, and insect-damaged fruits, washed, and subjected to floatation separation. The retained cherries were assigned to drying treatments and manually turned at regular intervals to promote uniform drying. Moisture content was monitored until the beans reached the target safe moisture range.

Sensory quality was evaluated through cupping tests conducted at the SKSU Coffee Cupping Laboratory and Barista Training Center by trained Q Robusta graders. Samples were assigned randomized three-digit codes for blind evaluation. The sensory attributes evaluated were aroma, flavor, aftertaste, salt–acid balance, bitter–sweet balance, mouthfeel, balance, overall cup quality, and cup score.

Statistical Analysis

Data were encoded and analyzed using the Statistical Tool for Agricultural Research. A two-factor factorial ANOVA under CRD was used to determine the effects of drying method, load volume, and their interaction. When significant differences were observed, the Least Significant Difference test at the 5% level of significance was applied.

RESULTS AND DISCUSSION

Drying Duration and Moisture Content

Drying method significantly affected drying duration. Bare concrete dried the coffee fastest with a mean of 18.00 days, followed by portable drying beds at 19.00 days and the dryer with plastic cover at 19.89 days. Load volume and the interaction between drying method and load volume were not significant, indicating that within the tested range of 5 to 15 kg/m², drying time was mainly determined by the drying structure rather than layer thickness.

Table 1. *Number of days to drying as influenced by drying method and load volume*

Drying Method	5 kg/m²	10 kg/m²	15 kg/m²	Mean
Bare Concrete	18.00	18.00	18.00	18.00c
Portable Drying Bed	19.00	19.00	19.00	19.00b
Dryer with Plastic Cover	19.67	20.00	20.00	19.89a
Mean	18.89ns	19.00ns	19.00ns	18.96

Note. Means with the same letter are not significantly different at the 5% level using LSD; ns = not significant

Moisture content also differed significantly by drying method. Portable drying beds produced the lowest final moisture content (12.14%), while the dryer with plastic cover had the highest (12.38%), with bare concrete intermediate (12.32%). Although the numerical differences were small, the result suggests that drying structures influence final moisture stability. All treatments generally reached safe storage levels, showing that each method can be used effectively when properly managed.

Table 2. *Moisture content of coffee beans as influenced by drying method and load volume*

Drying Method	5 kg/m²	10 kg/m²	15 kg/m²	Mean
Bare Concrete	12.27	12.30	12.40	12.32ab
Portable Drying Bed	12.10	12.10	12.23	12.14b
Dryer with Plastic Cover	12.37	12.30	12.47	12.38a
Mean	12.24ns	12.23ns	12.37ns	12.28

Note. Means with the same letter are not significantly different at the 5% level using LSD; ns = not significant

Sensory Quality Attributes

Aroma, flavor, aftertaste, mouthfeel, and balance were not significantly affected by drying method, load volume, or their interaction. However, the dryer with plastic cover and the 15 kg/m² load volume frequently produced the highest numerical values, indicating practical advantages despite the lack of statistical significance for some attributes. The stable scores suggest that the intrinsic quality of the Robusta beans was generally preserved across the treatments.

Table 3. Ar*oma score of coffee beans as influenced by drying method and load volume*

Drying Method	5 kg/m²	10 kg/m²	15 kg/m²	Mean
Bare Concrete	7.25	7.33	7.58	7.39ns
Portable Drying Bed	7.42	7.50	7.42	7.44ns

Dryer with Plastic Cover	7.50	7.42	7.59	7.50ns
Mean	7.39ns	7.42ns	7.53ns	7.44

Table 4. *Flavor score of coffee beans as influenced by drying method and load volume*

Drying Method	5 kg/m²	10 kg/m²	15 kg/m²	Mean
Bare Concrete	7.25	7.17	7.33	7.25ns
Portable Drying Bed	7.25	7.17	7.50	7.31ns
Dryer with Plastic Cover	7.42	7.33	7.50	7.42ns
Mean	7.31ns	7.22ns	7.44ns	7.32

Table 5. *Aftertaste score of coffee beans as influenced by drying method and load volume*

Drying Method	5 kg/m²	10 kg/m²	15 kg/m²	Mean
Bare Concrete	7.25	7.25	7.25	7.25ns
Portable Drying Bed	7.33	7.08	7.50	7.30ns
Dryer with Plastic Cover	7.25	7.33	7.58	7.39ns
Mean	7.28ns	7.22ns	7.44ns	7.31

Salt–acid balance was significantly affected by load volume. The 15 kg/m² treatment obtained the highest mean score of 7.67 and was significantly higher than the 5 kg/m² and 10 kg/m² treatments. This suggests that a thicker but still manageable coffee layer may slow moisture removal enough to preserve desirable acidity and brightness without producing negative sensory defects.

Table 6. *Salt–acid balance score of coffee beans as influenced by drying method and load volume*

Drying Method	5 kg/m²	10 kg/m²	15 kg/m²	Mean
Bare Concrete	7.42	7.25	7.67	7.44ns
Portable Drying Bed	7.33	7.17	7.67	7.39ns
Dryer with Plastic Cover	7.25	7.42	7.67	7.44ns
Mean	7.33b	7.28b	7.67a	

Bitter–sweet balance was significantly affected by both drying method and load volume. The dryer with plastic cover produced the highest mean score among drying methods, while 15 kg/m² produced the highest mean among load volumes. The A3B3 combination yielded the highest score of 7.67, suggesting that a semi-controlled environment combined with optimal layer thickness supports better sweetness expression and reduces harsh bitterness.

Table 7. *Bitter–sweet balance score of coffee beans as influenced by drying method and load volume*

Drying Method	5 kg/m²	10 kg/m²	15 kg/m²	Mean
Bare Concrete	7.25	7.25	7.33	7.28b
Portable Drying Bed	7.33	7.08	7.50	7.30b
Dryer with Plastic Cover	7.33	7.42	7.67	7.47a
Mean	7.30b	7.25b	7.50a	7.35

Table 8. *Mouthfeel score of coffee beans as influenced by drying method and load volume*

Drying Method	5 kg/m²	10 kg/m²	15 kg/m²	Mean
Bare Concrete	7.33	7.25	7.25	7.28ns
Portable Drying Bed	7.25	7.17	7.42	7.28ns
Dryer with Plastic Cover	7.25	7.33	7.58	7.39ns
Mean	7.28ns	7.25ns	7.42ns	7.31

Table 9. *Balance score of coffee beans as influenced by drying method and load volume*

Drying Method	5 kg/m²	10 kg/m²	15 kg/m²	Mean
Bare Concrete	7.25	7.25	7.33	7.28ns
Portable Drying Bed	7.25	7.08	7.42	7.25ns
Dryer with Plastic Cover	7.25	7.42	7.58	7.42ns
Mean	7.25ns	7.25ns	7.44ns	7.31

Overall cup quality and cup score were significantly influenced by load volume. The 15 kg/m² treatment consistently produced higher values than the 5 and 10 kg/m² treatments. The A3B3 treatment combination produced the highest overall cup quality score (7.58) and cup score (80.75), indicating that the dryer with plastic cover at 15 kg/m² is the most favorable combination for producing higher-quality Robusta coffee under the conditions of this study.

Table 10. *Overall cup quality score of coffee beans as influenced by drying method and load volume*

Drying Method	5 kg/m²	10 kg/m²	15 kg/m²	Mean
Bare Concrete	7.17	7.25	7.42	7.28ns
Portable Drying Bed	7.25	7.17	7.42	7.28ns
Dryer with Plastic Cover	7.33	7.42	7.58	7.44ns
Mean	7.25b	7.28b	7.47a	7.33

Table 11. *Cup score of coffee beans as influenced by drying method and load volume*

Drying Method	5 kg/m²	10 kg/m²	15 kg/m²	Mean
Bare Concrete	78.17	78.00	79.17	78.44ns
Portable Drying Bed	78.42	77.42	79.83	78.56ns
Dryer with Plastic Cover	78.58	79.08	80.75	79.47ns
Mean	78.39b	78.17b	79.92a	78.82

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Figure 4. Experimental layout of the study.

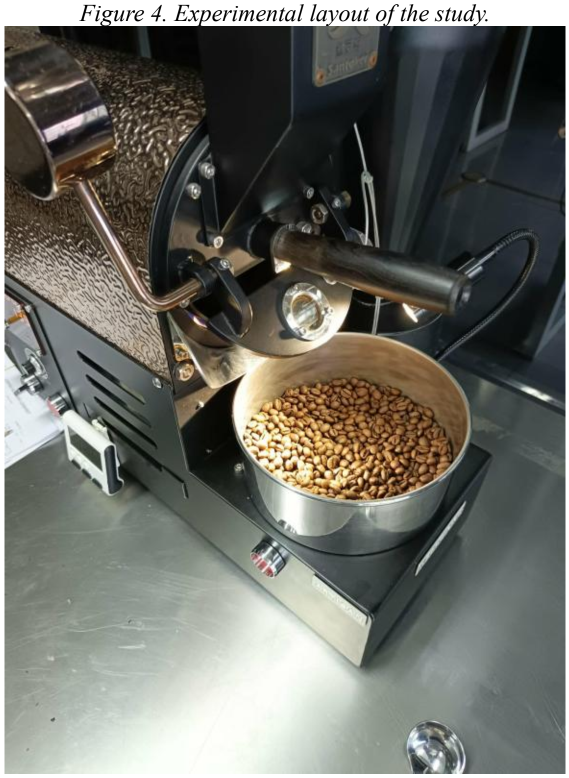

Figure 5. Harvesting and preparation of Robusta coffee cherries

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Figure 6. Preparation for the cupping test

CONCLUSION

The study concluded that drying method significantly influenced drying duration and moisture content. Bare concrete achieved the shortest drying time, while the dryer with plastic cover required the longest duration. Portable drying beds produced the lowest final moisture content. These results indicate that drying structure affects drying behavior and moisture stability.

Load volume significantly influenced key sensory characteristics, particularly salt–acid balance, overall cup quality, and cup score. The 15 kg/m² load volume consistently produced the highest sensory performance, showing that this level can improve cup quality without compromising drying efficiency under the tested conditions.

Drying method had limited statistical influence on most sensory attributes, but the dryer with plastic cover significantly improved bitter–sweet balance and consistently produced higher numerical scores. The best treatment combination was the dryer with plastic cover at 15 kg/m², which recorded the highest values in flavor, aftertaste, bitter–sweet balance, mouthfeel, balance, overall cup quality, and cup score.

Recommendation

Coffee producers and processors are encouraged to adopt a standard load volume of 15 kg/m² for Robusta coffee drying because this level consistently improved sensory quality without negatively affecting drying duration and moisture content.

Controlled drying systems, especially plastic-covered dryers, are recommended where resources allow because they may provide more stable temperature and humidity conditions and improve bitter–sweet balance and overall sensory consistency.

Farmer groups, processors, and local agricultural agencies may use the dryer with plastic cover at 15 kg/m² as a practical postharvest protocol for producing higher-quality Robusta coffee. Standardized drying procedures should be promoted to reduce quality variation and strengthen the market competitiveness of South Cotabato Robusta coffee.

Future researchers should test wider load volumes, other coffee varieties, multiple harvest seasons, and different climatic conditions to validate the results and refine load-volume recommendations across production contexts. Microbial and chemical analyses may also be included to better explain sensory differences.

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